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ABSTRACT

This exercise teaches undergraduate geography students to use the Lorenz Curve and the Index of Dissimilarity to assess the spatial distributions of the White, Black, and American Indian populations of the United States in 1980. Specific procedures for implementing the exercise are provided; solutions to the exercise are also included. Students used the "Statistical Abstract of the United States, 1982-1983" as the source of their data. The exercise was initially designed to be used in an introductory quantitative methods class where the students had minimal statistical and computer skills. As students' quantitative and computer skills have improved, variations of the exercise have been used. For example, the students now analyze the spatial distributions of the three ethnic populations at the census division, state, and county levels. The Lorenz Curve for the 50 U.S. states and the 67 counties of Alabama and the indices of dissimilarity are illustrated. The data of the original exercise were also used to develop exercises for the Friedman's Rank Sums and Kruskal-Wallis One Way Analysis of Variance and to illustrate the spatial inequality of U.S. ethnic populations in introductory human geography courses. (RM)

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EVALUATING THE SPATIAL DISTRIBUTIONS OF ETHNIC POPULATIONS: A QUANTITATIVE EXERCISE FOR UNDERGRADUATES

by

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EVALUATING THE SPATIAL DISTRIBUTIONS OF ETHNIC POPULATIONS: A QUANTITATIVE EXERCISE FOR UNDERGRADUATES

I. INTRODUCTION

The purpose of this paper is to describe a quantitative exercise for undergraduates which focuses upon two quantitative techniques which can be used to assess inequalities between spatial distributions. The Lorenz Curve and the Index of Dissimilarity will be used to assess the spatial distributions of the White, Black, and American Indian populations of the United States in 1980.

II. EXERCISE: ASSESSING INEQUALITIES IN SPATIAL DISTRIBUTIONS

A. INTRODUCTION

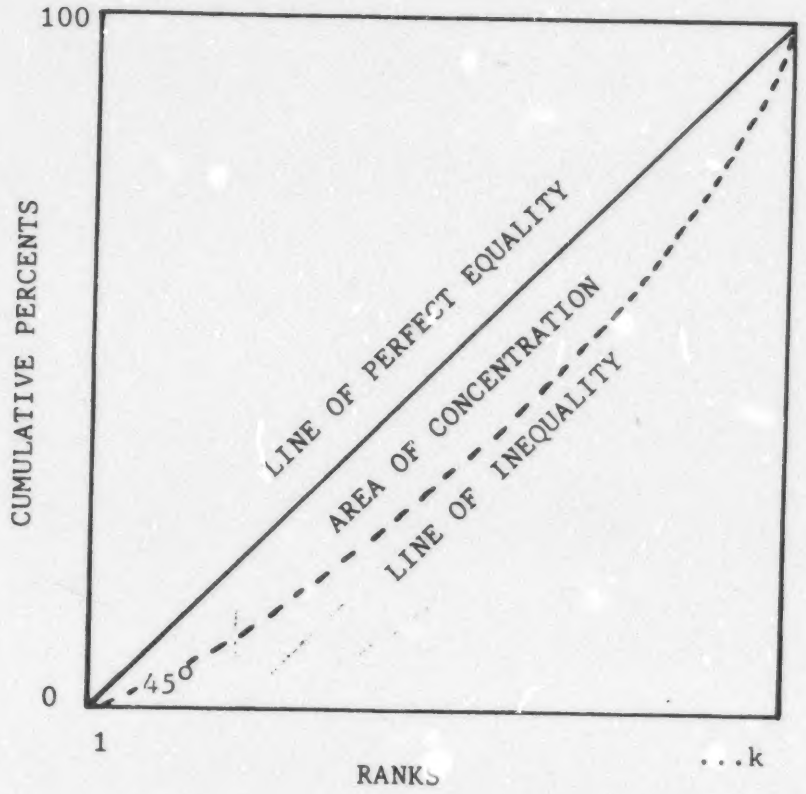
The purpose of this exercise is to introduce you to the Lorenz Curve and the Index of Dissimilarity, which can be used to quantitatively assess inequalities in spatial distributions. The primary sources for this assignment are: R. Hammon and P. S. McCullagh, QUANTITATIVE TECHNIQUES IN GEOGRAPHY: AN INTRODUCTION, Oxford: Clarendon Press, 1974 and P. J. Taylor, QUANTITATIVE METHODS IN GEOGRAPHY: AN INTRODUCTION TO SPATIAL ANALYSIS, Prospect Heights, Ill.: Waveland Press, 1983.

B. LORENZ CURVE

Introduction

The Lorenz Curve is a graph which illustrates the similarities in the spatial distributions of areal data, Figure One. If the spatial distributions of the areal data are equal they will correspond to a diagonal line drawn at a 45^{o} angle which is called the line of perfect equality. Deviation from the line of perfect equality will illustrate the inequality in the areal data's spatial distributions.

FIGURE ONE: LORENZ CURVE



The cumulative frequencies or percents of the areal data are plotted along the Y axis, while the rank order of the cumulative frequencies is plotted along the X axis. The diagonal represents perfect equality in the ranking of the cumulative frequencies, while the line of inequality represents the actual relationship between the rank of some variable X and its respective cumulative frequency. The area between the two lines represents the area of concentration. The further the line of inequality is from the line of perfect equality, the more inequality there is in the spatial distribution of the areal data.

Limitations

Given that the technique uses cumulative frequencies negative numbers such as those derived in population change studies and continuous data such as temperature cannot be used.

Procedure

1. Calculate the % of the total distribution of variable X for each areal unit under study.
2. Rank the percent's for variable X from smallest to largest.
3. Calculate a cumulative frequency for variable X.
4. Plot the cumulative frequency data for variable X on graph paper joining the points to create the curve (Hammond and McCullagh, 1974, p. 16-20).

Data

The exercise will focus upon the spatial distributions of three ethnic groups in the United States: White, Black and American Indian, Table One. The source of this data is the STATISTICAL ABSTRACT OF THE UNITED STATES, 1982-1983. You should become familiar with this data source as it could be very useful to you throughout your career.

Table One: Ethnic Populations

(in thousands)

	US Pop.	White Pop.	Black Pop.	Am. Indian Pop.
New England	12348	11586	475	21.6
Middle Atlantic	36787	30741	4374	57.4
East North Central	41682	36150	4549	105.9
West North Central	17183	16044	789	142.5
South Atlantic	36959	28659	7652	118.7
East South Central	14666	11702	2869	22.5
West South Central	23747	18599	3527	231.0
Mountain	11373	9961	269	364.4
Pacific	31800	24929	1993	356.4
TOTAL:	226546	188372	26495	1420.4

Source: Statistical Abstract of the United States: 1982-1983, p. 32.

Graph

Use the graph paper (5 squares to the centimeter) provided with the exercise and plot the cumulative frequencies of the White, Black and American Indian populations such that the cumulative frequencies of the ethnic groups are plotted along the Y axis and the ranks 1 to 9, which correspond to the number of census divisions, are plotted along the X axis. Draw a diagonal line at a 45^{o} angle.

C. INDEX OF DISSIMILARITY

The index of dissimilarity is a statistic which assesses the maximum vertical distance between the diagonal of perfect equality and the line of inequality of the Lorenz Curve. The formula for the index is:

$$D_a = \frac{\left| X_i - Y_i \right|}{2}$$

The index of dissimilarity equals the sum of the absolute differences between the frequencies of variable X and variable Y divided by two. The index ranges from 0% to 100% where 0% is defined as perfect equality and 100% is defined as perfect inequality (Taylor, 1983, pp. 179-180).

III. SOLUTION TO THE EXERCISE

A. Lorenz Curve

Step 1: The percentages of the total populations for each ethnic group are shown in Table Two.

Step 2: The ranks of the percentages for each ethnic group are shown alongside the percentages in parentheses in Table Two.

Step 3: The cumulative frequencies for each ethnic group are shown in Table Three.

Table Two: Percentage Data

Census Division	% of Total US Population	% of Total US White Pop.	% of Total US Black Pop.	% of Total Am. Indian Pop.
New England	5.45	6.15 (2)	1.79 (2)	1.52 (1)
Middle Atlantic	16.24	16.32 (8)	16.51 (7)	4.04 (3)
East North Central	18.40	19.19 (9)	17.17 (8)	7.46 (4)
West North Central	7.58	8.52 (4)	2.98 (3)	10.03 (6)
South Atlantic	16.31	15.21 (7)	28.88 (9)	8.36 (5)
East South Central	6.47	6.21 (3)	10.83 (5)	1.58 (2)
West South Central	10.48	9.87 (5)	13.31 (6)	16.26 (7)
Mountain	5.02	5.29 (1)	1.02 (1)	25.66 (9)
Pacific	14.04	1[illegible]23 (6)	7.52 (4)	25.09 (8)

(Rank of percentage from smallest to largest.)

Table Three: Cumulative Frequencies Data

% Total US White Population	% Total US Black Population	% Total American Indian Population
5.29	1.02	1.52
11.44	2.81	3.10
17.65	5.79	7.14
26.17	13.31	14.60
36.04	24.14	22.96
49.27	37.45	32.99
64.68	53.96	49.25
80.08	71.13	74.34
99.99	100.00	100.00

Step 4: Plots of the cumulative frequencies for the three ethnic groups are shown in Figure Two.

B. INDEX OF DISSIMILARITY

Referring to the frequency data shown on Table Two, where X_1 equals the percentage of the total US population, and Y_1 equals the percentage of the total White population, Y_2 equals the percentage of the total Black population, and Y_3 equals the percentage of the total American Indian population. The calculated differences are shown in Table Four as are the sums of the absolute differences, and the index of dissimilarities for each ethnic group. There is almost equality in the distribution of the White population as compared to the total US population, while the American Indian population has the most unequal distribution of the three major ethnic groups in the United States.

IV. MULTI-PURPOSE EXERCISE

A. STATE/COUNTY ANALYSES

This exercise was initially designed to be used in an introductory quantitative methods class where the students had minimal statistical and computer skills. As the students' quantitative and computer skills have improved over the years variations of the exercise have been developed. The students are now responsible for analyzing the spatial distributions of the three ethnic populations at the census division, state, and county levels. Figures Three and Four illustrate, respectively, the Lorenz Curve for the 50 US states (plus the District of Washington) and the 67 counties of Alabama. The indices of dissimilarity for the three ethnic groups are shown in Table 5. It can be seen that the spatial distributions of the three ethnic groups are unequal for all three spatial scales, however a word of caution is needed. Because the Lorenz Curve and the Index of Dissimilarity are sensitive to areal size, the

FIGURE TWO: CENSUS DIVISIONS

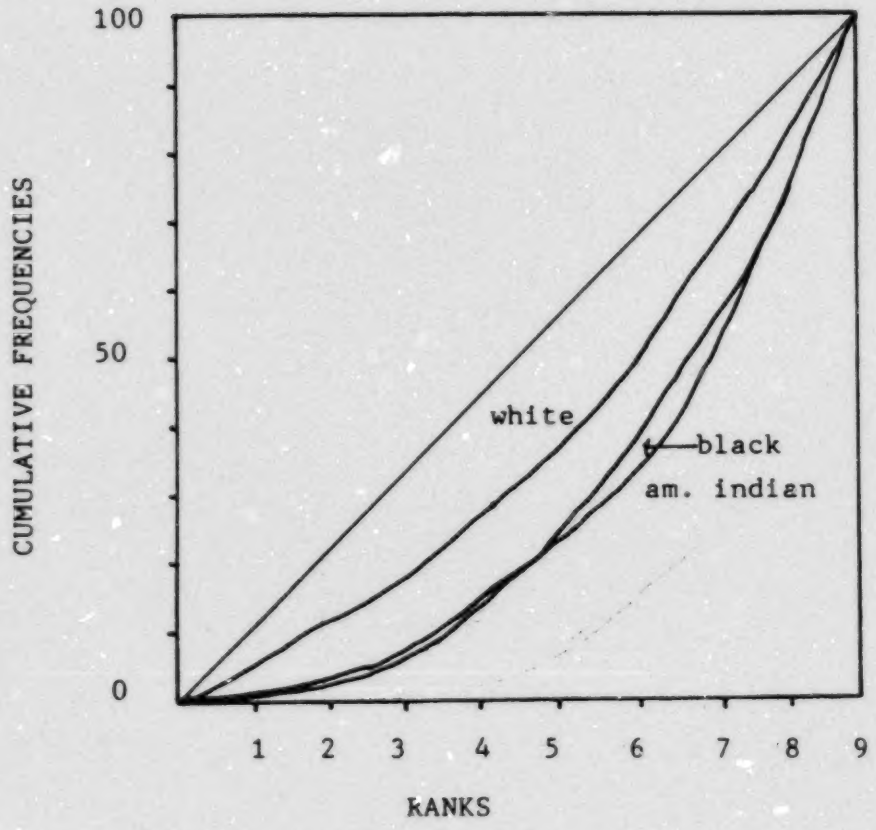


Table Four: Differences Between Ethnic Frequencies

	White Pop. (X_1-Y_1)	Black Pop. (X_1-Y_2)	Am. Indian Pop. (X_1-Y_3)
New England	-0.70	3.66	3.93
Middle Atlantic	- .08	- .27	12.20
East North Central	- .79	1.23	10.94
West North Central	- .94	4.60	-2.45
South Atlantic	1.10	-12.57	7.95
East South Central	.26	- 4.36	4.89
West South Central	.61	- 2.83	-5.78
Mountain	- .27	4.0	-20.64
Pacific	.81	6.52	-11.05
$\Sigma \lvert X_i-Y_i \rvert$	5.56	40.04	79.83
D_A =	2.78	20.02	39.92

FIGURE THREE: STATES

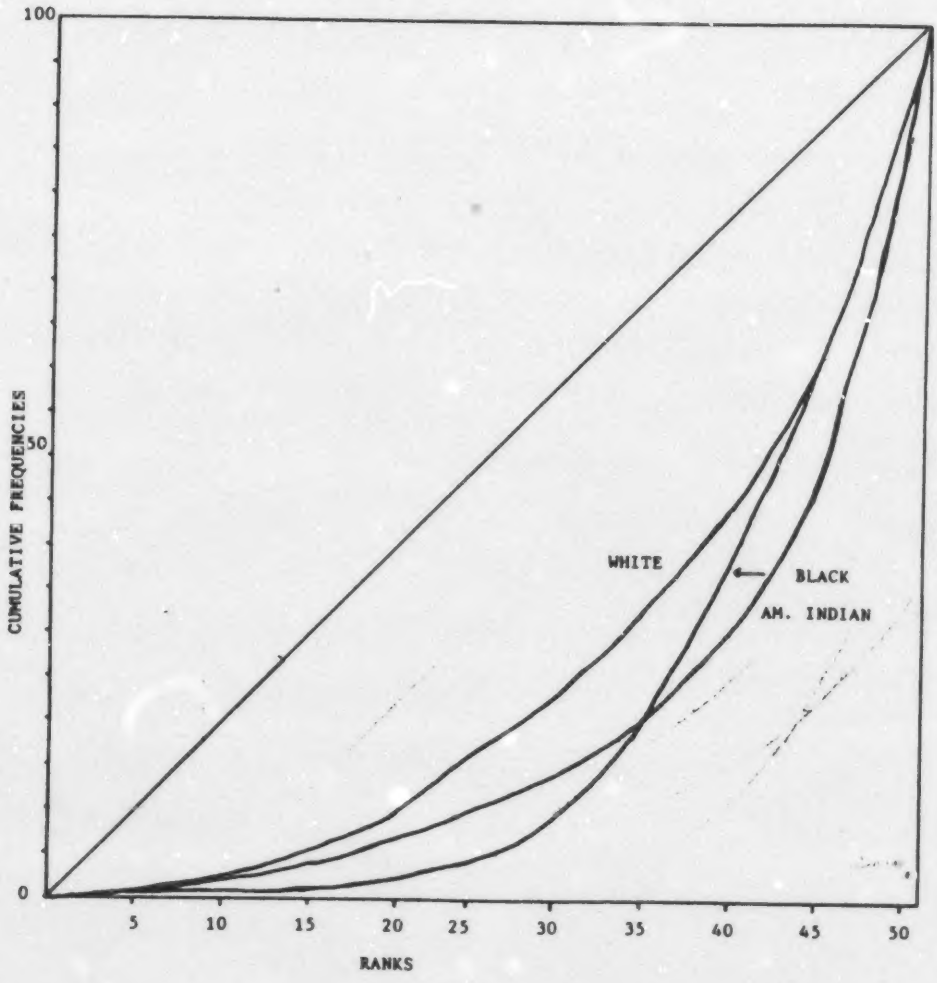


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FIGURE FOUR: COUNTIES

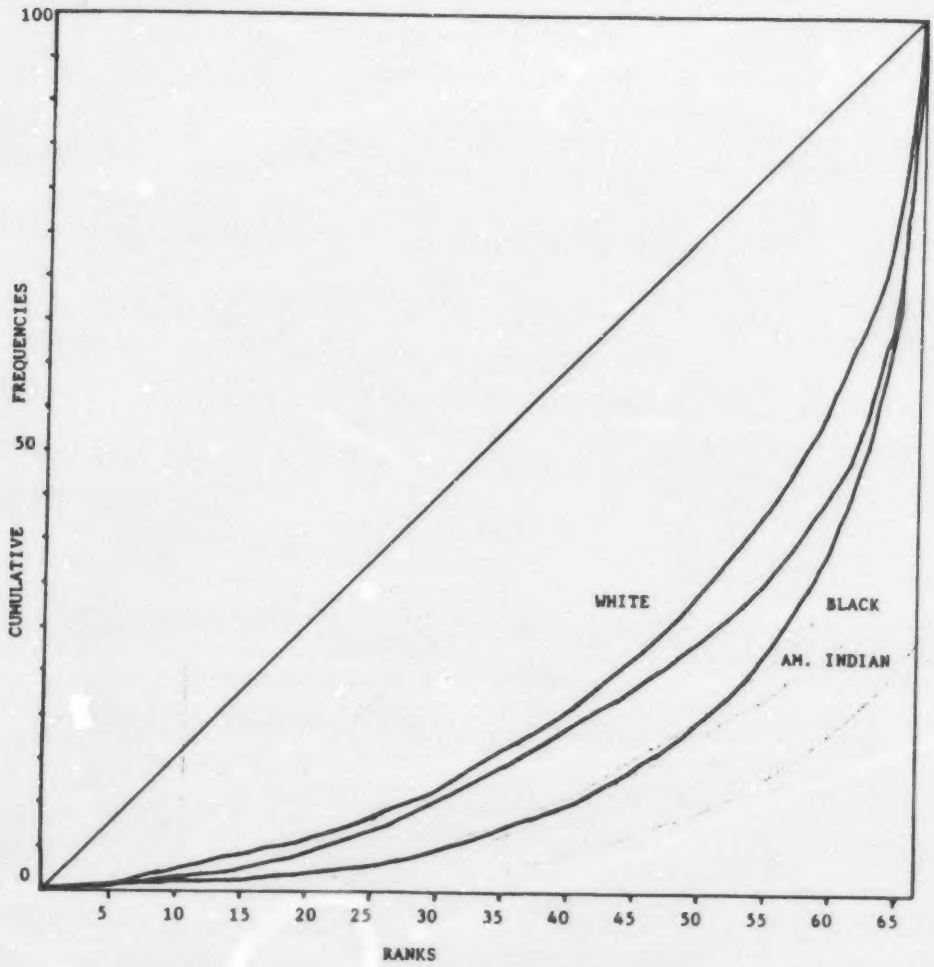

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Table Five: Indices of Dissimilarity

	White Pop.	Black Pop.	Am. Indian Pop.
Census Divisions	2.78	20.02	39.92
States	4.03	24.43	49.18
Counties of Alabama	15.92	23.08	59.72

graphs and the indices cannot be compared between the different spatial scales. Generally, the Lorenz Curve and the Index of Dissimilarity become smaller when the number of areal units decreases.

B. ADDITIONAL ANALYSES

The data of the original exercise was also used in developing exercises for the Friedman's Rank Sums and Kruskal-Wallis One Way Analysis of Variance. The students benefitted from using the data again because they could see that any particular set of data can be analyzed with a number of different techniques each of which is designed to elicit different information about the data.

C. NONQUANTITATIVE APPLICATIONS

Finally, the results of the three spatial analyses were used in an introductory human geography course to illustrate the spatial inequality of ethnic populations in the USA. This served as the conclusion to an introduction to migration to and within the United States. The discussion of the curves and the indices of dissimilarities also served to reenforce the need for geographers to have statistical training.

V. SUMMARY

Exercises such as the one described in this paper should be applicable in a variety of different quantitative contexts as well as in a variety of different classes. Students will be able to appreciate the multifaceted nature of quantitative analysis as well as the applicability of quantitative results in nonquantitative courses. Instructors will also benefit from multipurpose exercises as they will allow the instructor a greater return for her/his efforts.

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